TABLE OF CONTENTS

Tables

Figures

TABLE OF CONTENTS

As described in Section 2, building blocks are combined to define trial scenarios that offer insight into the risk-reduction benefits to more than one asset or resource in the Sacramento–San Joaquin River Delta (Delta), Suisun Marsh, and statewide. The four scenarios considered in Phase 2 were identified in Section 2, “Building Blocks and Scenarios” in terms of the building blocks that constitute each trial scenario. This section describes the results of the evaluation of the four trial scenarios.

The first section describes the scenario evaluation steps. The remaining sections describe the results of the four scenario evaluations.

18.1 SCENARIO EVALUATION

As described in Section 2, a trial scenario is a collection of building blocks that is intended to provide risk-reduction benefits to the Delta and the state. Each trial scenario, which is a conceptual-level development, is evaluated to assess its risk reduction potential. The steps in this process generally consist of the following:

- Evaluate the reduction in the frequency of levee failures and island flooding from the base case (“business as usual”) for seismic and flood events for each trial scenario that offers some benefit or improvement to the reliability of Delta levees. Risk reduction for sunny-day failures is considered to be negligible because the risk contribution of sunny-day failures to the overall risk is minor.
- Assess the reduction in the duration of water export disruption from the base case due to improved protection to water conveyance.
- Estimate the economic costs and impacts in years 2005, 2050, and 2100 for each trial scenario, taking into account the building block changes (e.g., elevating state roads, reductions in water export disruptions) and the risk increases in future years.
- Estimate the risk-reduction benefit of each trial scenario in terms of the difference in the present worth of the risk costs and impacts between the base case (Phase 1 results) and the trial scenario results and determine the net present value of the risk reduction.

In considering each trial scenario, the functional/physical interface of the building blocks as they are joined in a scenario is considered. These considerations include the physical layout of different building blocks, the potential cost savings, and ultimately the combined risk benefit. For example, Scenarios 2 and 4 (Through-Delta Conveyance and Dual Conveyance) include upgrading of selected Delta islands to Public Law (PL) 84-99 standards and seismically upgrading the levees along the armored pathway. Where levees are considered for seismic upgrade, they are removed from the 764 miles of PL 84-99 levees.

However, a building block that offers individual benefits to an area where it is implemented (e.g., seismically upgrading 20 miles of levees) may in the context of a trial scenario (the larger picture) offer relatively small benefits when viewed in the context of the Delta and the state.

18.2 TRIAL SCENARIO 1: IMPROVED LEVEES

18.2.1 Overview of Trial Scenario 1

The elements of Trial Scenario 1 are illustrated in Figure 18-1, and the building blocks composing this trial scenario are listed in Table 18-1. Trial Scenario 1 focuses on improving levee performance to mitigate the high likelihood of failures due to floods.

Other highlights of this trial scenario include improved levee maintenance, enhanced emergency preparedness, raising state highways to minimize the impact to state transportation, creating an armored infrastructure corridor to protect transportation and utility lines, and implementing a number of environmental restorations, including tidal marsh restoration at Cache Slough, the installation of fish screens, the construction of setback levees to create shaded riverine aquatic (SRA) habitat, carbon sequestration at selected islands, and land use changes at selected islands.

18.2.2 Evaluation of Trial Scenario 1

Elements of the Delta Risk Management Strategy (DRMS) Phase 1 risk model are used to evaluate the risk-reduction benefits of Trial Scenario 1. This evaluation considers the effects of building blocks on the likelihood of levee failure and island flooding and the reduction in the consequences of levee failures.

As discussed in Section 5 (Building Block 1.3: Enhanced Emergency Preparedness/Response), an alternative strategy to that used in the Phase 1 analysis (which was based on a “business-as-usual” approach) is suggested. However, the benefits of an alternative strategy could not be explicitly assessed in this analysis. The business-as-usual” strategy is still used.

In this trial scenario, the major state highways in the Delta would be elevated and would not be damaged significantly by levee failure. However, some time would be needed to inspect the highways, their bridges, and the armored corridor levees and to conduct minor repairs, particularly when a large number of islands are flooded. The reduction in highway downtime is assessed to be 95 percent when fewer than five islands are flooded and 90 percent when more islands are flooded.

18.2.2.1 Levee Failure

A number of the building blocks that would be implemented under Trial Scenario 1 are designed to improve the reliability of Delta levees, including improvements in levee maintenance and upgrading central Delta levees to meet PL 84-99 standards. These building blocks have been considered in the Delta risk model, and they would reduce the likelihood of Delta islands being flooded.

About 764 miles of levees are improved under this trial scenario to meet PL 84-99 standards and about 187 miles of levees are improved to meet urban levee standards. The improvements include levee widening and additional freeboard. The risk of levee failure from flood events is reduced by only 10 percent for the under-seepage and through-seepage failure modes and by 80 percent for the overtopping failure mode. Taking into account the relative frequency of failure of these three failure modes, the overall reduction in the risk of levee failure is calculated to be 24 percent. There is no reduction in the seismic risk of levee failure.

18.2.2.2 Emergency Response and Water Export Disruption

The duration and cost of levee repairs for Trial Scenario 1 are assessed to be generally comparable to those in Phase 1. As stated previously, the duration of water export disruption is assessed to be similar to that of the base case; hence, no improvement to the risk of water export interruption occurs. As in Phase 1, other water quality issues (e.g., organic carbon, turbidity) that may impact water treatment and use are not evaluated.

18.2.2.3 Consequences

The consequences associated with levee failures and island flooding events are evaluated for seismic and flood events. The in-Delta costs, given the flooding of specific islands, are about the same for the trial scenarios and the base case, because the emergency response and repair costs for the trial scenarios are comparable to those of base case. Other cost components (infrastructure repair, agriculture losses, lost use of structures and services, and lost recreation) are also similar, given similar response and repair time. However, the statewide costs under the trial scenarios are less because of the reduced water export disruption and minimal damage to state highways.

Tables 18-2a and 18-2b show the percent reduction in the economic costs and impacts for different numbers of flooded islands due to seismic events. Table 18-3 shows the reduction in economic costs for flood events. No changes in economic impacts are expected for a flood event under the different trial scenarios because no water export disruption occurs for such events and highway damage causes little economic impact.

For seismic events, the percent reduction in the economic cost (as shown in Table 18-2b) is relatively small (about 2.2 percent) when fewer than five islands are flooded and higher (by about 17 percent to 36 percent) when five or more islands are flooded. The risk reduction to the economic costs is mainly due to the prevention of highway damage. No reduction occurs in the potential economic impacts (value of lost output) associated with Trial Scenario 1 because the economic impacts are mainly due to loss of water export, and this scenario does not include a building block that improves water export reliability.

For flood events, the percent reduction in the economic cost (as shown in Table 18-3) is again relatively small (about 10 percent) when the number of flooded islands is five or less and much larger (about 55 percent) when the number of flooded islands is greater than five. The main reason for this difference is the much higher traffic disruption that results from multiple damaged highways within the existing Delta when a large number of islands are flooded. Water export is not affected by salinity intrusion for flood-initiated levee failures because of the large inflows of freshwater into the Delta during these conditions. However, increased turbidity and dissolved organic carbon may impact water treatment and uses. These effects are not addressed in this evaluation.

18.2.2.4 Scenario Costs

Table 18-4 lists the capital costs of implementation of all four trial scenarios. The costs listed are based on the cost estimates of the individual building blocks, taking into account efficiencies of combining different building blocks (such as the reduced cost of levee improvements associated with the armored pathway). The future year evaluations for the base case and all four trial scenarios assume that levee improvements, conveyance improvements, and highway raises throughout the Delta keep up with or include accommodations for sea-level rise.

18.2.2.5 Risk-Reduction Benefit

The expected consequences (costs and impacts) are calculated for the base case and each trial scenario during each of the following three years: 2005, 2050, and 2100. The main steps and results are summarized below.

The expected consequences for the base case in 2005 are calculated by multiplying the frequency of a given number of flooded islands by the corresponding consequences and summing the product over the entire range of the number of flooded islands. This calculation is made separately for seismic and flood events, and the resulting expected values are summed to obtain the total expected consequence.

The expected consequences for each trial scenario in 2005 are calculated by applying appropriate reduction factors to the frequency of flooding different numbers of islands and to the corresponding consequences. The reduction factors reflect the benefits of improvements under each trial scenario.

For each future year—2050 and 2100—the growth factors for hazard, fragility, and consequences included in the Phase 1 report are applied to the 2005 base case values. The expected consequences in 2050 and 2100 for the base case are then calculated by using the corresponding values of the frequency of events, levee fragility, and consequences. For each trial scenario, the growth factors for hazard and consequences are the same as those for the base case, because these growth factors are a function of the increase in population and the built environment and are not affected by the trial scenarios. However, the growth in levee fragility is affected by the improvements because the rate of growth in fragility would be smaller for improved levees. Table 18-5 summarizes the growth factors for 2050 and 2100 for the base case and the four trial scenarios.

The expected consequences for each intermediate year between 2005 and 2050 and between 2050 and 2100 are obtained by linear interpolation. All future costs are converted to present worth using a net discount rate of 4 percent and summed to obtain the total present-worth cost of the base case and each trial scenario. The difference between the total present-worth cost of the base case and a given trial scenario is considered to be the benefit of that scenario. This benefit can be compared to the capital cost of implementing the scenario.

Figure 18-2a shows a plot of the expected cost of the base case and each trial scenario in 2005, 2050, and 2100, and Figure 18-2b shows the same costs without the base case. Figures 18-3a and 18-3b show similar plots for the expected economic impacts. Table 18-6 summarizes the costs and benefits of the different trial scenarios. Life-safety benefits for the trial scenarios are realized because of the reduced frequency of island flooding from seismic and flood events. The percent reduction in the frequency of life loss is estimated as the average of the percent reduction in the frequency of island flooding due to seismic and flood events.

18.3 TRIAL SCENARIO 2: THROUGH-DELTA CONVEYANCE (ARMORED PATHWAY)

18.3.1 Overview of Trial Scenario 2

The elements of Trial Scenario 2 are shown in Figure 18-4. Table 18-7 lists the building blocks that are combined to form Trail Scenario 2. This scenario focuses on improving the reliability of water export capability by creating an armored pathway through the Delta to mitigate the high likelihood of saltwater intrusion at the export pumps as a result of levee failures due to seismic events. The elements of this scenario include seismic setback levees along the entire alignment of the armored pathway, flow control gates at junctions with other rivers and sloughs, and an intake and fish-screening facility at the Sacramento River intake, as shown in Figure 18-4.

Other highlights of this trial scenario include improved levee maintenance, enhanced emergency preparedness, upgrading about 764 miles of Delta levees to PL 84-99 standards and 187 miles to urban levee standards, raising state highways to minimize the impact to state transportation, building an armored infrastructure corridor, and a number of environmental actions, such as tidal marsh and wetland restorations in Suisun Marsh and Cache Slough, carbon sequestration at selected islands, and the placement of fish screens at river diversions.

18.3.2 Evaluation of Trial Scenario 2

This scenario improves the reliability of water export by seismically upgrading the levees along the proposed pathway and hence the name “Armored Pathway.” The armored pathway is designed to recover water conveyance functionality in a timely manner (as compared with the base case) after a seismic event. However, the risk that many Delta islands will be flooded is not significantly reduced under this trial scenario, because levees that do not define the armored pathway are not improved for seismic performance and remain as vulnerable as before. The reduction in economic costs and impacts due to raised state highways are similar to those under Trial Scenario 1.

18.3.2.1 Levee Failure

The building blocks implemented under Trial Scenario 2 are designed to improve the reliability of the Delta levees that define the armored pathway. The levees that define the armored pathway are seismically upgraded and will meet or exceed urban levee standards. As a result, these levees are considerably more reliable than the remaining Delta island levees. The levees that define the armored pathway make up only a small fraction of the total length of Delta levees. As a result, the likelihood of island flooding will not be improved in any substantial way under this scenario. The seismic improvement of the levees is partial on few islands and non-existent on the remaining islands. Therefore, the reduction in the frequency of island flooding due to seismic events is very small.

On balance, the risk of islands flooding due to seismic events is slightly (about 2 percent) lower under this scenario than the Phase 1 result. Approximately 10 percent of the Delta levees are upgraded, and a large fraction of each island that has some length of upgraded levee is still as vulnerable as it was previously. The reduction in the risk of islands flooding due to hydrological (flood) events is about 24 percent, the same as that for Trial Scenario 1. However, for levees along the armored pathway that fail as a result of a seismic event, water conveyance will be recovered relatively quickly (return to functionality quicker) for the design earthquake (200-year return period).

18.3.2.2 Consequences

The armored pathway is expected to have reduced water export disruption periods after seismic events. However, saltwater flowing to adjacent flooded islands is expected to initially contaminate (as a result of saltwater intrusion) the pathway. This salinity will need to be flushed out. As shown in Table 18-2b, the water export disruption is reduced by about 90 percent for fewer than five flooded islands, but then the percent reduction to water export reduction becomes smaller to negligible for larger and lager numbers of flooded islands.

For flood events, the expected reduction in consequences is primarily due to elevated and protected state highways, which are similar to benefits under Trial Scenario 1.

18.3.2.3 Scenario Costs

The capital cost of implementing Trial Scenario 2 is shown in Table 18-4. These costs are based on the cost estimates of the individual building blocks, the efficiencies of combining different building blocks, and annual costs (increased annual funding for levee maintenance).

18.3.2.4 Risk-Reduction Benefit

The resulting risk reductions for Trial Scenario 2 are shown in Table 18-6. The reduction in the expected cost is somewhat greater than for Trial Scenario 1 because of the greater reliability of the armored pathway in protecting water exports during seismic events.

18.4 TRIAL SCENARIO 3: ISOLATED CONVEYANCE FACILITY

18.4.1 Overview of Trial Scenario 3

The elements of Trial Scenario 3 are depicted in Figure 18-5. Table 18-8 lists the building blocks that are combined to form Trial Scenario 3. This scenario focuses on improving the reliability of water exports by constructing an Isolated Conveyance Facility (ICF) to the east of the Delta to mitigate the high likelihood of levee failures and subsequent saltwater intrusion to the export pumps due to seismic events and floods. This ICF will include intake structures and fish screening at the upstream connection with the Sacramento River.

Other highlights of this trial scenario include improved levee maintenance, enhanced emergency preparedness, upgrading about 764 miles of Delta levees to PL 84-99 standards and 187 miles of Delta levees to urban standards, raising state highways to minimize the impact to state transportation, and a number of environmental actions, such as tidal marsh and wetland restorations in Suisun Marsh and Cache Slough, SRA habitat along selected rivers, carbon sequestration on selected islands, and the placement of fish screens at river diversions.

18.4.2 Evaluation of Trial Scenario 3

By constructing an ICF, the capability to convey water to the State Water Project and Central Valley Project pumps in the south Delta is no longer dependent on the performance of Delta levees. Further, because the seismic vulnerability of Delta levees remains unchanged, the frequency of occurrence of levee failures and island flooding remains the same as estimated in the Phase 1 analysis (base case). Similarly, the in-Delta consequences for Trial Scenario 3 also remain essentially the same.

The benefits of the ICF are twofold. First, the reliability of water conveyance to the pumps in the south Delta will be considerably higher. The ICF will have a seismic design that is comparable to that of the seismically upgraded levees (see Section 4). Further, the ICF will not be vulnerable to the flooding of Delta islands or floods less than the 100-year flood event. As a result, the likelihood of ICF damage or failure will be considerably less than that of Delta levees.

Second, the repairs that would be required to the ICF canal, structures, and equipment if damages are incurred, in particular from a seismic event, will be able to be made from land. In this analysis, it is assumed that the repairs required to return the ICF to service can be made in a short period (3 months or less in most cases, possibly a bit longer in other cases). If the period of repair is 3 months or less, the economic costs of an event will be limited to in-Delta costs.

18.4.2.1 Consequences

The ICF is expected to remain functional during the design seismic event. As shown in Table 18-2b, the water export disruption under seismic events will be reduced by about 100 percent for all flooded island combinations, and the impact to traffic interruption is reduced by 95 percent to 100 percent because of the construction of elevated highways. The impact to the in-Delta costs will remain similar to that of Trial Scenario 1. The average reduction in total cost is estimated to be about 2.3 percent for fewer than five flooded islands and 37 percent to 38 percent for five or more flooded islands. The average reduction in total economic impacts is estimated to be about 1.5 percent for five or fewer flooded islands and about 47 percent for more than five flooded islands.

For hydrological (flood) events, the expected reduction in consequences will result primarily from elevated and protected state highways, which are similar to the benefits realized under Trial Scenario 1.

18.4.2.2 Scenario Costs

The capital cost of implementing Trial Scenario 3 is shown in Table 18-4. These costs are based on the cost estimates of the individual building blocks and the efficiencies of combining different building blocks. The detailed breakdown of the cost estimates for the ICF is included in Appendix 9B.

18.4.2.3 Risk-Reduction Benefit

The results of the risk reduction benefits for present and future years are shown in Table 18-6. The risk reduction benefits for Trial Scenario 3 are the highest of the trial scenarios because it provides a more reliable water export component while sharing the same improvement benefits with the other trial scenarios, such as the strengthening of the transportation and utility infrastructure and levee improvements.

18.5 TRIAL SCENARIO 4: DUAL CONVEYANCE

18.5.1 Overview of Trial Scenario 4

The elements of Trial Scenario 4 are depicted in Figure 18-6. Table 18-9 lists the building blocks that are combined to form Scenario 4, which focuses on improving the reliability of water exports by creating an armored pathway through the Delta and constructing an ICF to the east of the Delta to mitigate the likelihood of levee failures and saltwater intrusion to the export pumps due to seismic events and floods. This facility will include intake structures and fish screens at the upstream connection with the Sacramento River.

Other highlights of this scenario include improved levee maintenance, enhanced emergency preparedness, upgrading about 764 miles of Delta levees to PL 84-99 standards and about 187 miles of levees to urban standards, raising state highways to minimize the impact to state transportation, and a number of environmental actions, such as tidal marsh and wetland restorations in Suisun Marsh and Cache Slough, restoration of SRA habitat along the armored pathway, carbon sequestration at selected islands, and the placement of fish screens at river diversions.

18.5.2 Evaluation of Trial Scenario 4

As its name implies, the Dual Conveyance scenario has two components: an Isolated Conveyance Facility and a Through-Delta Conveyance (Armored Pathway). Each component is evaluated separately below.

18.5.2.1 Isolated Conveyance Component

The construction associated with a Dual Conveyance scenario envisions a capability to convey water to the State Water Project and the Central Valley Project pumps in the south Delta that is no longer dependent on the performance of Delta levees. Because the seismic vulnerability of Delta levees remains unchanged under this scenario, the frequency of occurrence of levee failures and island flooding remains the same as estimated in the Phase 1 analysis. Similarly, the in-Delta consequences of Trial Scenario 4 remain essentially the same as in the Phase 1 analysis.

The benefits of the Dual Conveyance scenario are twofold. First, the reliability of water conveyance to the pumps in the south Delta will be considerably higher than the reliability of the Delta levees. The Isolated Conveyance component of the Dual Conveyance scenario would have a seismic design that is comparable to that of the seismically upgraded levees of the Through-Delta Conveyance (see Section 8). Further, the Isolated Conveyance component of the Dual Conveyance scenario will not be vulnerable to the flooding of Delta islands or floods that are less than the 100-year flood event. As a result, the likelihood that the Isolated Conveyance component of the Dual Conveyance scenario will be damaged or fail will be considerably less than likelihood that the Delta levees will fail.

Second, the repairs that would be required to the Isolated Conveyance canal, structures, and equipment if damages are incurred, in particular from a seismic event, will be able to be made from land. In this analysis, it is assumed that the repairs required to return the Isolated Conveyance component of the Dual Conveyance scenario to service can be made in a short period (3 months or less in most cases, possibly a bit longer in other cases). If the period of repair is 3 months or less, the economic costs of an event will be limited to in-Delta costs.

18.5.2.2 Armored Pathway Component

The building blocks implemented as part of Trial Scenario 2 are designed to improve the reliability of the Delta levees that define the armored pathway component of the Dual Conveyance scenario. The levees that define the armored pathway component of the Dual Conveyance scenario will be seismically upgraded and will meet or exceed urban levee standards. As a result, these levees are considerably more reliable than individual Delta islands with respect to seismic events. The levees that define the armored pathway component of the Dual Conveyance scenario make up a fraction of the total length of levees on the individual islands where they exist. However, because the improvement on each island has been partial, the reduction in the frequency of island flooding due to seismic events in particular is small.

On balance, the risk of islands flooding due to seismic events is slightly (about 2 percent) lower than under Phase 1. Approximately 10 percent of Delta levees are upgraded under this scenario, and a large fraction of each island that has some length of upgraded levee is still as vulnerable as it was previously. The reduction in the risk of islands flooding due to hydrological (flood) events is about 24 percent, the same as that for Trial Scenario 1. As a result, for a seismic event the armored pathway will recover functionality more quickly for the design earthquake (200-year return period).

The Dual Conveyance scenario will have lower conveyance capacity than Trial Scenario 3 but will provide greater reliability for water export than Trial Scenario 2. The reduction in the duration of water export disruption for Trial Scenario 4 is assessed to be approximately the average of the reductions for Trial Scenarios 2 and 3.

18.5.2.3 Consequences

The Dual Conveyance scenario is expected to remain functional during the design seismic and flood events. As shown in Table 18-2b, the water export disruption under seismic events would be reduced by about 95 percent for fewer than five flooded islands and by about 50 percent to 85 percent for five or more flooded islands. The impact to traffic interruption is reduced by 95 percent to 100 percent because of the construction of elevated highways. The impact to the in-Delta costs will remain similar to that of Trial Scenario 1. The average reduction in total cost is estimated to be about 2.3 percent for fewer than five flooded islands and 27 percent to 38 percent for five or more flooded islands. The average reduction in total economic impacts is estimated to be about 1.4 percent for five or fewer flooded islands and about 23 percent to 30 percent for more than five flooded islands.

For hydrological (flood) events, the expected reduction in consequences would be primarily due to elevated and protected state highways, which is similar to Trial Scenario 3.

18.5.2.4 Scenario Costs

The capital cost of implementing Trial Scenario 4 is shown in Table 18-4. These costs are based on the cost estimates for the individual building blocks and the efficiencies of combining different building blocks.

18.5.2.5 Risk Reduction Benefit

The results of the risk reduction benefits for present and future years are shown in Table 18-6. The risk reduction benefits for Trial Scenario 4 are the second highest behind the benefits for Trial Scenario 3. The reason that this scenario has a high risk reduction ranking is because it provides a more reliable water export component while sharing the same improvement benefits with the other trial scenarios, such as the strengthening of transportation and utility infrastructure and levee improvements.

Tables

Table 18-1 Building Blocks for Trial Scenario 1 (Improved Levees)

No.	Building Block	Option
1.1a	Improved Delta Levee Maintenance	Increase Delta Levee Subventions Program spending to ~$12 million/year (twice the current level)
1.2a	Upgraded Delta Levees	Upgrade Delta Levees to Public Law 84-99 standards (about 764 miles)
1.3	Enhanced Emergency Preparedness/Response	Spend ~$50 million for pre-positioning of rock, sheetpiles, etc.
1.5	Land Use Changes to Reduce Island Subsidence	Change land use from farming to wetlands/carbon sequestration (e.g., rice growing, fish food farm) for all islands projected to have more than 3 feet of additional subsidence by 2100
2.1	Raise State Highways and Place on Piers (similar to I-80 across Yolo Bypass)	Raise State Routes 12 and 160.
2.2	Construct Armored Infrastructure Corridor Across Central Delta	Include Mokelumne Aqueduct, BNSF railroad, State Route 4, and natural gas pipelines in armored corridor
3.1	Suisun Marsh Tidal Wetland Restoration	Restore Suisun Marsh tidal wetland
3.2	Cache Slough Tidal Marsh Restoration	Restore Cache Slough tidal marsh
3.3a	Install Fish Screens	Install fish screens in agricultural river diversions
3.4a	Setback levees to Restore Shaded Riverine Habitat	Restore 30 miles of shaded riverine habitat along Sutter and Steamboat sloughs and San Joaquin widening

Table 18-2a Percent Reduction in Economic Costs and Impacts from Base Case under Seismic Events for Different Trial Scenarios: Base Case Results

(a) Base Case Results

Number of Flooded Islands	Statewide Cost as % of Total Cost	% of Statewide Cost due to Water Export Disruption	% of Statewide Cost due to Highway Damage	% of Value of Lost Output due to Water Export Disruption
1	2%	0.4%	100%	1%
3	2%	0.4%	100%	1%
5	38%	0.4%	100%	1%
10	38%	51.5%	48%	47%
15	38%	51.5%	48%	47%
20	38%	51.5%	48%	47%
30	38%	51.5%	48%	47%
50	38%	51.5%	48%	47%

Table 18-2b Percent Reduction in Economic Costs and Impacts from Base Case under Seismic Events for Different Trial Scenarios: Trial Scenario Results

Scenario	Number of Flooded Islands	% Reduction in Duration of Water Supply Disruption	% Reduction in Highway Impacts	% Reduction in Statewide Cost	Average % Reduction in Total Cost	Percent Reduction in Value of Lost Output
1	1	0%	95%	95%	2.2%	0.0%
	3	0%	95%	95%	2.2%	0.0%
	5	0%	95%	95%	36.2%	0.0%
	10	0%	90%	44%	16.7%	0.0%
	15	0%	90%	44%	16.7%	0.0%
	20	0%	90%	44%	16.7%	0.0%
	30	0%	90%	44%	16.7%	0.0%
	50	0%	90%	44%	16.7%	0.0%
2	1	90%	95%	95%	2.2%	1.3%
	3	90%	95%	95%	2.2%	1.3%
	5	70%	95%	95%	36.3%	1.0%
	10	30%	90%	59%	22.6%	14.1%
	15	0%	90%	44%	16.7%	0.0%
	20	0%	90%	44%	16.7%	0.0%
	30	0%	90%	44%	16.7%	0.0%
	50	0%	90%	44%	16.7%	0.0%
3	1	100%	100%	100%	2.3%	1.5%
	3	100%	100%	100%	2.3%	1.5%
	5	100%	100%	100%	38.2%	1.5%
	10	100%	95%	98%	37.3%	47.1%
	15	100%	95%	98%	37.3%	47.1%
	20	100%	95%	98%	37.3%	47.1%
	30	100%	95%	98%	37.3%	47.1%
	50	100%	95%	98%	37.3%	47.1%
4	1	95%	100%	100%	2.3%	1.4%
	3	95%	100%	100%	2.3%	1.4%
	5	85%	100%	100%	38.2%	1.3%
	10	65%	95%	80%	30.4%	30.6%
	15	50%	95%	72%	27.4%	23.6%
	20	50%	95%	72%	27.4%	23.6%
	30	50%	95%	72%	27.4%	23.6%
	50	50%	95%	72%	27.4%	23.6%

Table 18-3 Percent Reduction in Economic Costs from Base Case under Flood Events for Different Trial Scenarios

Scenario	Number of Flooded Islands	Base Case Statewide Cost as % of Total Cost	Base Case % of Statewide Cost due to Highway Damage	% Reduction in Highway Impacts	% Reduction in Total Cost
All Trial Scenarios	1	10%	100%	95%	10%
	3	10%	100%	95%	10%
	5	10%	100%	90%	9%
	10	61%	100%	90%	55%
	20	61%	100%	90%	55%
	30	61%	100%	90%	55%

Table 18-4 Capital Costs of Implementation for Different Trial Scenarios

Trial Scenario 1 (Improved Levees)	Cost ($M)	Trial Scenario 2 (Through Delta Conveyance)	Cost ($M)	Scenario 3 (Isolated Conveyance)	Cost ($M)	Scenario 4 (Dual Conveyance)	Cost ($M)
Upgrade Delta levees to Public Law 84-99 standards (764 miles)	1,158	Upgrade Delta levees to Public Law 84-99 standards (764 miles)	991	Upgrade Delta levees to Public Law 84-99 standards (764 miles)	1,158	Upgrade Delta levees to Public Law 84-99 standards (764 miles)	991
Upgrade Delta Levees to urban levee standards (187 miles)	-	Upgrade Delta Levees to urban levee standards (187 miles)	754	Upgrade Delta Levees to urban levee standards (187 miles)	754	Upgrade Delta Levees to urban levee standards (187 miles)	754
Enhance emergency preparedness/response ($50M/year)	50	Enhance emergency preparedness/response ($50M/year)	50	Enhance emergency preparedness/response ($50M/year)	50	Enhance emergency preparedness/response ($50M/year)	50
Change land use to reduce subsidence	60	Change land use to reduce subsidence	60	Change land use to reduce subsidence	60	Change land use to reduce subsidence	60
Raise State Routes 12 and 160	4,400	Armored pathway (seismic resistant levees)	5,049	Full Isolated Conveyance Facility (ICF) (15,000 cfs)	4,960	Dual Conveyance (ICF, 10,000 cfs)	4,200
Construct Armored Infrastructure Corridor	3,300	Raise State Routes 12 and 160	4,400	Raise State Routes 4, 12, and 160	6,100	Dual Conveyance (Armored Pathway, 5,000 cfs)	3,700
Restore Suisun Marsh tidal wetland	167	Construct armored infrastructure corridor	3,300	Restore Suisun Marsh tidal wetland	167	Raise State Routes 4, 12, and 160	6,100
Restore Cache Slough and Yolo Bypass tidal marsh	410	Restore Suisun Marsh tidal wetland	167	Restore Cache Slough and Yolo Bypass tidal marsh	410	Restore Suisun Marsh tidal wetland	167
Install fish screens at agricultural river diversions	165	Restore Cache Slough and Yolo Bypass tidal marsh	410	Install fish screens at ICF and agricultural river diversions	439	Restore Cache Slough and Yolo Bypass tidal marsh	410
Construct setback levees for shaded riverine habitat (30 miles)	720	Install fish screens at TDC and agricultural river diversions	439	Construct setback levees for shaded riverine habitat (30 miles)	720	Install fish screens at ICF, TDC, and agricultural river diversions	713
Totals	**10,430**		**15,620**		**14,817**		**17,145**

ICF = Isolated Conveyance Facility
TDC = Through-Delta Conveyance

Table 18-5 Risk Growth Factors for 2050 and 2100

Scenario	Risk Component	% Increase for 2050 Seismic Risk	% Increase for 2100 Seismic Risk	% Increase for 2050 Flood Risk	% Increase for 2100 Flood Risk
Base Case and All Trial Scenarios	Hazard (frequency of events)	10%	20%	194%	458%
	Economic Consequences (cost or impact)	123%	211%	128%	255%
	Loss of Life	158%	N/A	128%	N/A
All Trial Scenarios	Growth Rate for Fragility of Improved Levees	5%	10%	5%	10%
Trial Scenario 1 (Improved Levees)	Levee Fragility (probability of failure given a stressing event)	23%	61%	7%	15%
Trial Scenario 2 (Through-Delta Conveyance [Armored Pathway])	Levee Fragility (probability of failure given a stressing event)	21%	56%	7%	15%
Trial Scenario 3 (Isolated Conveyance Facility)	Levee Fragility (probability of failure given a stressing event)	23%	61%	7%	15%
Trial Scenario 4 (Dual Conveyance)	Levee Fragility (probability of failure given a stressing event)	23%	61%	7%	15%

Table 18-6 Summary of Costs and Benefits of Trial Scenarios

Cost/Benefit Component	Scenario 1: Improved Levees	Scenario 2: Through Delta Conveyance (Armored Pathway)	Scenario 3: Isolated Conveyance Facility	Scenario 4: Dual Conveyance
Capital cost ($billion present value)	10.4	15.6	14.8	17.1
Reduction in expected economic losses from base case during 2005 to 2050 ($billion present value)	69.0	70.9	83.3	79.9
Reduction in expected economic losses from base case during 2005 to 2100 ($billion present value)	123.1	126.2	143.7	139.7
Reduction in expected value of lost output from base case during 2005 to 2050 ($billion present value)	8.7	9.1	12.4	11.3
Reduction in expected value of lost output from base case during 2005 to 2100 ($billion present value)	17.9	18.4	23.0	21.8
Reduction in the frequency of life-loss events from base case during 2005 to 2050	11%	12%	11%	11%

Table 18-7 Building Blocks for Trial Scenario 2 (Through-Delta Conveyance [Armored Pathway])

No.	Building Block	Option
1.1	Improved Delta Levee Maintenance	Increase Delta Levee Subventions Program spending to ~$12 million/year (twice the current level)
1.2a,b	Upgraded Delta Levees	Upgrade Delta Levees to Public Law 84-99 standards (about 764 miles); upgrade Delta Levees to urban standards (about 187 miles)
1.3	Enhanced Emergency Preparedness/Response	Spend ~$50 million for pre-positioning rock, sheetpiles, etc.
1.5	Land Use Changes to Reduce Island Subsidence	Change land use from farming to wetlands/carbon sequestration (e.g., rice growing, fish food farm) for all islands projected to have more than 3 feet of additional subsidence by 2100
1.6	Armored “Pathway” (Through-Delta Conveyance)	Seismically upgrade levees along “pathway.” install a series of seven gates and dredge sections of channel
2.1a	Raise State Highways and Place on Piers (similar to I-80 across Yolo Bypass)	Raise State Routes 12 and 160
2.2a	Construct Armored Infrastructure Corridor Across Central Delta	Include Mokelumne Aqueduct, BNSF railroad, State Route 4, and natural gas pipelines in armored corridor
3.1	Suisun Marsh Tidal Wetland Restoration	Restore Suisun Marsh tidal wetland
3.2	Cache Slough Tidal Marsh Restoration	Restore Cache Slough tidal marsh, including Yolo Bypass
3.3a,b	Install Fish Screens	Install fish screens at armored pathway intake facility and agricultural river diversions
3.4	Setback Levee to Restore Shaded Riverine Habitat	Included in armored pathway (~100 miles of setback levees)

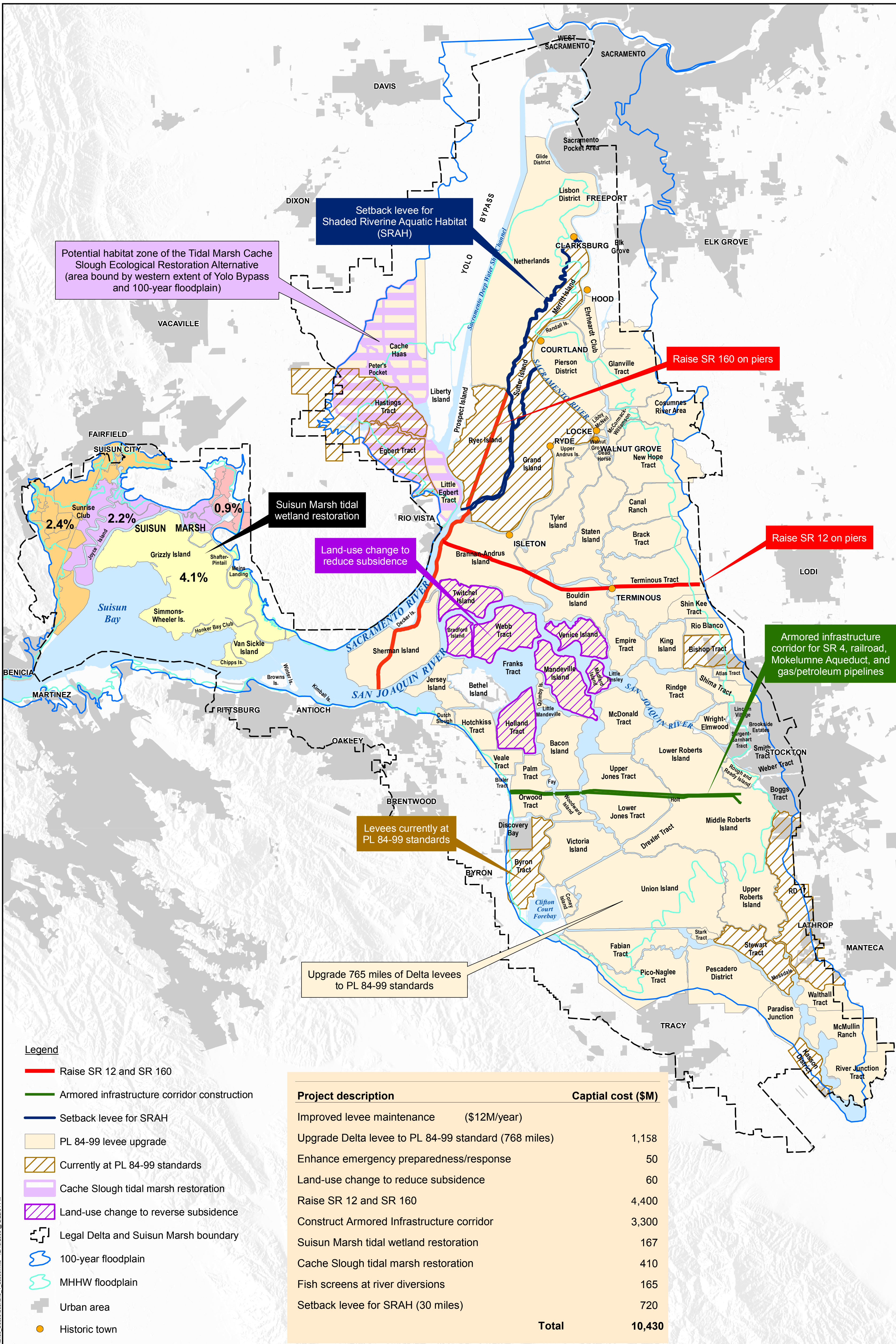
Table 18-8 Building Blocks for Trial Scenario 3 (Isolated Conveyance Facility)

No.	Building Block	Option
1.1	Improved Delta Levee Maintenance	Increase Delta Levee Subventions Program spending to ~$12 million/year (twice the current level)
1.2a,b	Upgraded Delta Levees	Upgrade levees to Public Law 84-99 standards (about 764 miles); upgrade Delta levees to urban levee standards (about 187 miles)
1.3	Enhanced Emergency Preparedness/Response	Spend ~$50 million for pre-positioning rock, sheetpiles, etc.
1.5	Land Use Changes to Reduce Island Subsidence	Change land use from farming to wetlands/carbon sequestration (e.g., rice growing, fish food farm) for all islands projected to have more than 3 feet of additional subsidence by 2100
1.7c	Isolated Conveyance Facility (15,000 cfs)	Construct a full-capacity (15,000 cfs) Isolated Conveyance Facility along the eastern edge of the Delta
2.1	Raise State Highways and Place on Piers (similar to I-80 across Yolo Bypass)	Raise State Routes 4, 12, and 160
3.1	Suisun Marsh Tidal Wetland Restoration	Restore Suisun Marsh tidal wetland
3.2	Tidal Marsh Cache Slough Restoration	Restore Cache Slough tidal marsh
3.3a,c	Install Fish Screens	Install fish screens for Isolated Conveyance Facility intake and agricultural river diversions
3.4a	Setback levees to Restore Shaded Riverine Habitat	Restore 30 miles of shaded riverine habitat

Table 18-9 Building Blocks for Trial Scenario 4 (Dual Conveyance)

No.	Building Block	Option
1.1	Improved Delta Levee Maintenance	Increase Delta Levee Subventions Program spending to ~$12 million/year (twice the current level)
1.2a,b	Upgraded Delta Levees	Upgrade Delta levees to Public Law 84-99 standards (about 764 miles); upgrade Delta levees to urban levee standards (about 187 miles)
1.3	Enhanced Emergency Preparedness/Response	Spend ~$50 million for pre-positioning rock, sheetpiles, etc.
1.5	Land Use Changes to Reduce Island Subsidence	Change land use from farming to wetlands/carbon sequestration (e.g., rice growing, fish food farm) for all islands projected to have more than 3 feet of additional subsidence by 2100
1.6	Armored “Pathway” Through Delta Conveyance	Seismically upgrade levees along “armored pathway” (5,000 cfs); install a series of seven salinity control gates, and dredge sections of channel
1.7b	Isolated Conveyance Facility	Construct a reduced-capacity (10,000 cfs) Isolated Conveyance Facility along the eastern edge of the Delta
2.1	Raise State Highways and Place on Piers (similar to I-80 across Yolo Bypass)	Raise State Routes 4, 12, and 160
3.1	Suisun Marsh Tidal Wetland Restoration	Restore Suisun Marsh tidal wetland
3.2	Tidal Marsh Cache Slough Restoration	Restore Cache Slough tidal marsh
3.3a-c	Install Fish Screens	Install fish screens at armored “pathway” intake facility, Isolated Conveyance component intake facility, and agricultural river diversions

Figures



Project description	Captial cost ($M)
Improved levee maintenance (\$12M/year)	
Upgrade Delta levee to PL 84-99 standard (768 miles)	1,158
Enhance emergency preparedness/response	50
Land-use change to reduce subsidence	60
Raise SR 12 and SR 160	4,400
Construct Armored Infrastructure corridor	3,300
Suisun Marsh tidal wetland restoration	167
Cache Slough tidal marsh restoration	410
Fish screens at river diversions	165
Setback levee for SRAH (30 miles)	720
Total	**10,430**

URS

Project No. 26815935

Delta Risk Management Strategy (DRMS)
Phase 2
10 Dec 2008

Trial Scenario 1:
Improved Levees

Figure
18-1

P:\GIS\GIS_Phase_II_Project_Files\MXD\Scenarios_Dec08\Scenario_1_dec08.mxd - 12/18/2008 @ 2:22:34 PM

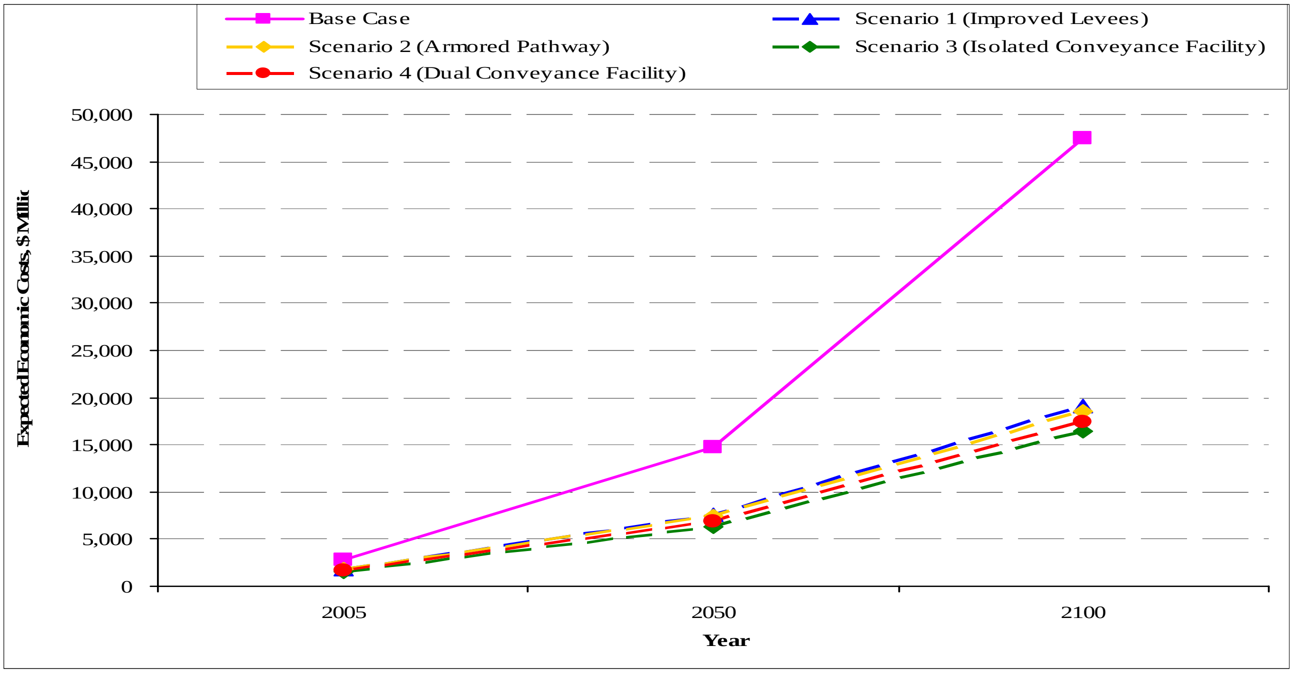


Figure 18-2a Expected Economic Costs of Trial Scenarios at Different Years, Including Base Case

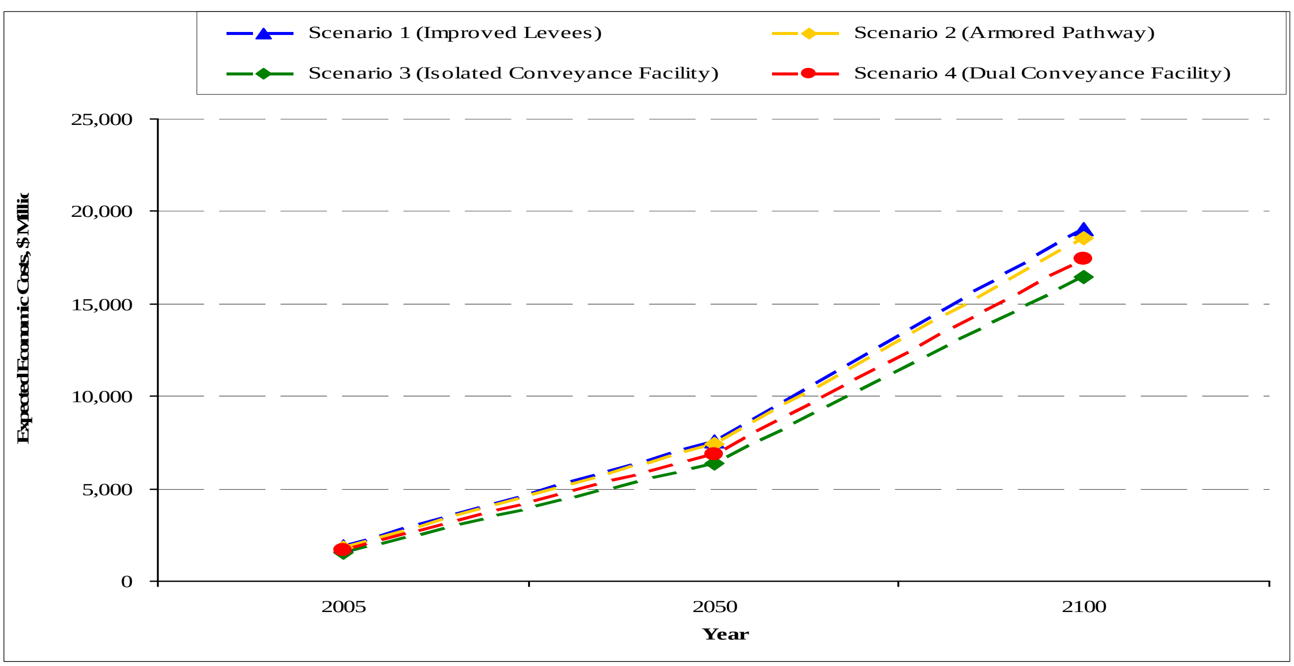


Figure 18-2b Expected Economic Costs of Trial Scenarios at Different Years

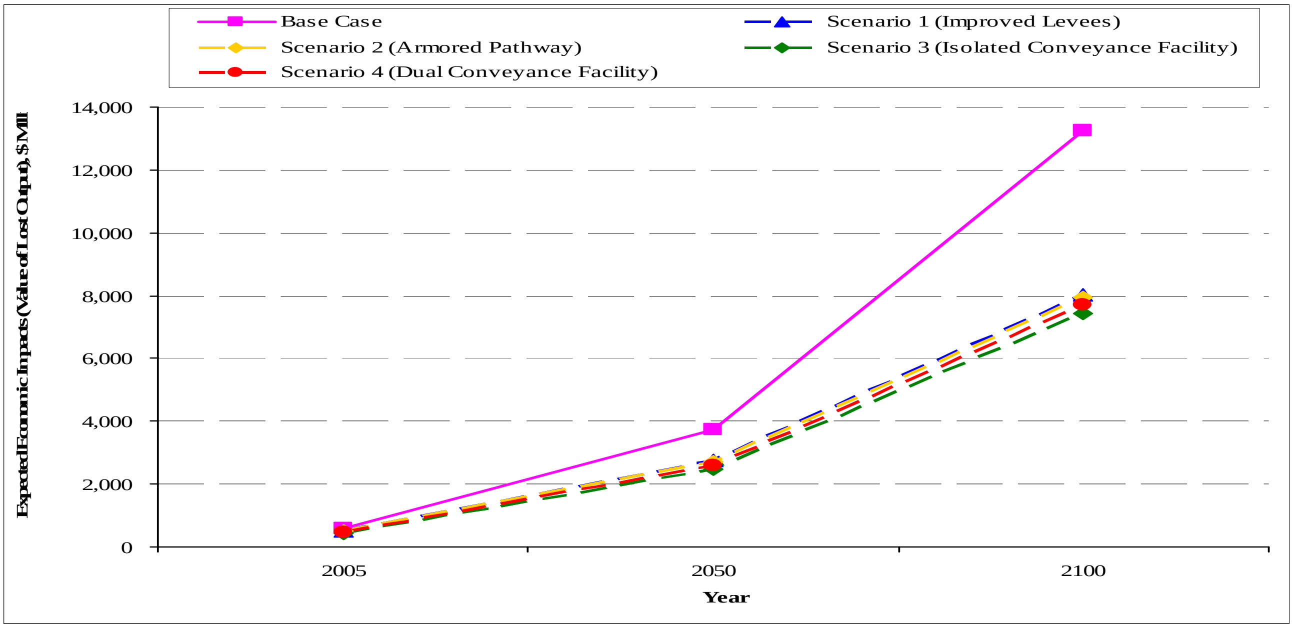


Figure 18-3a Expected Economic Impacts (Value of Lost Output) of Trial Scenarios at Different Years, Including the Base Case

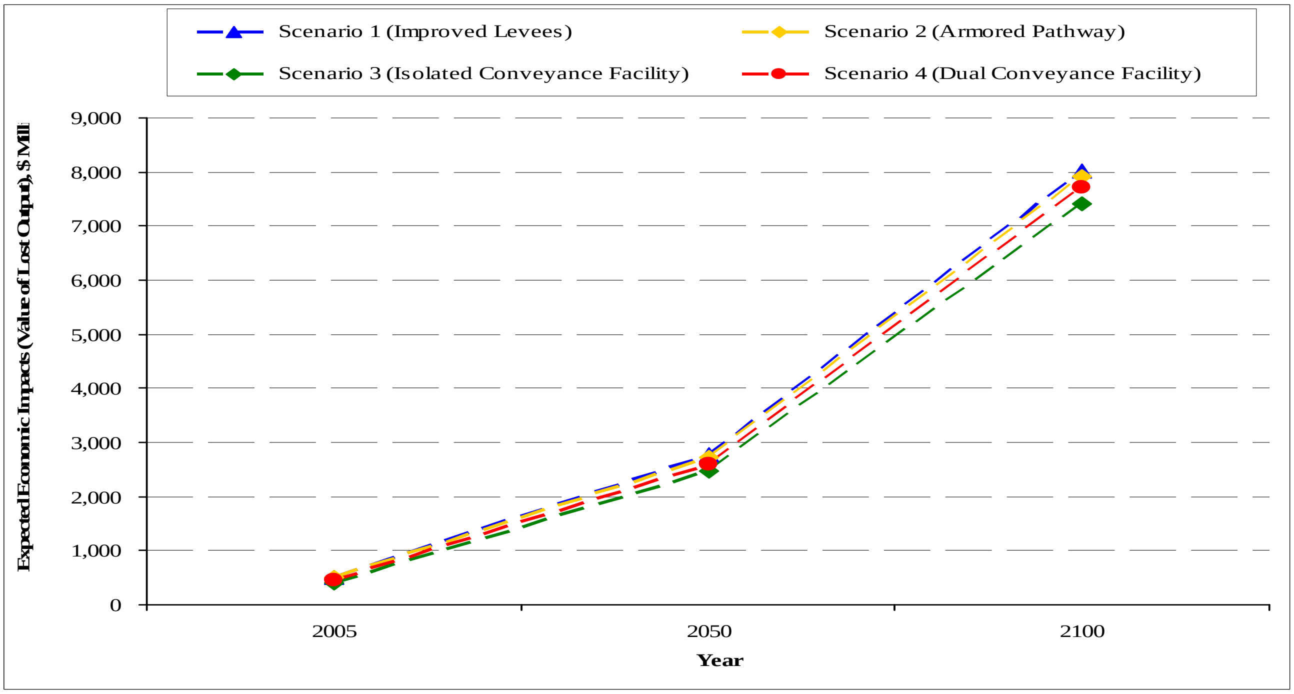
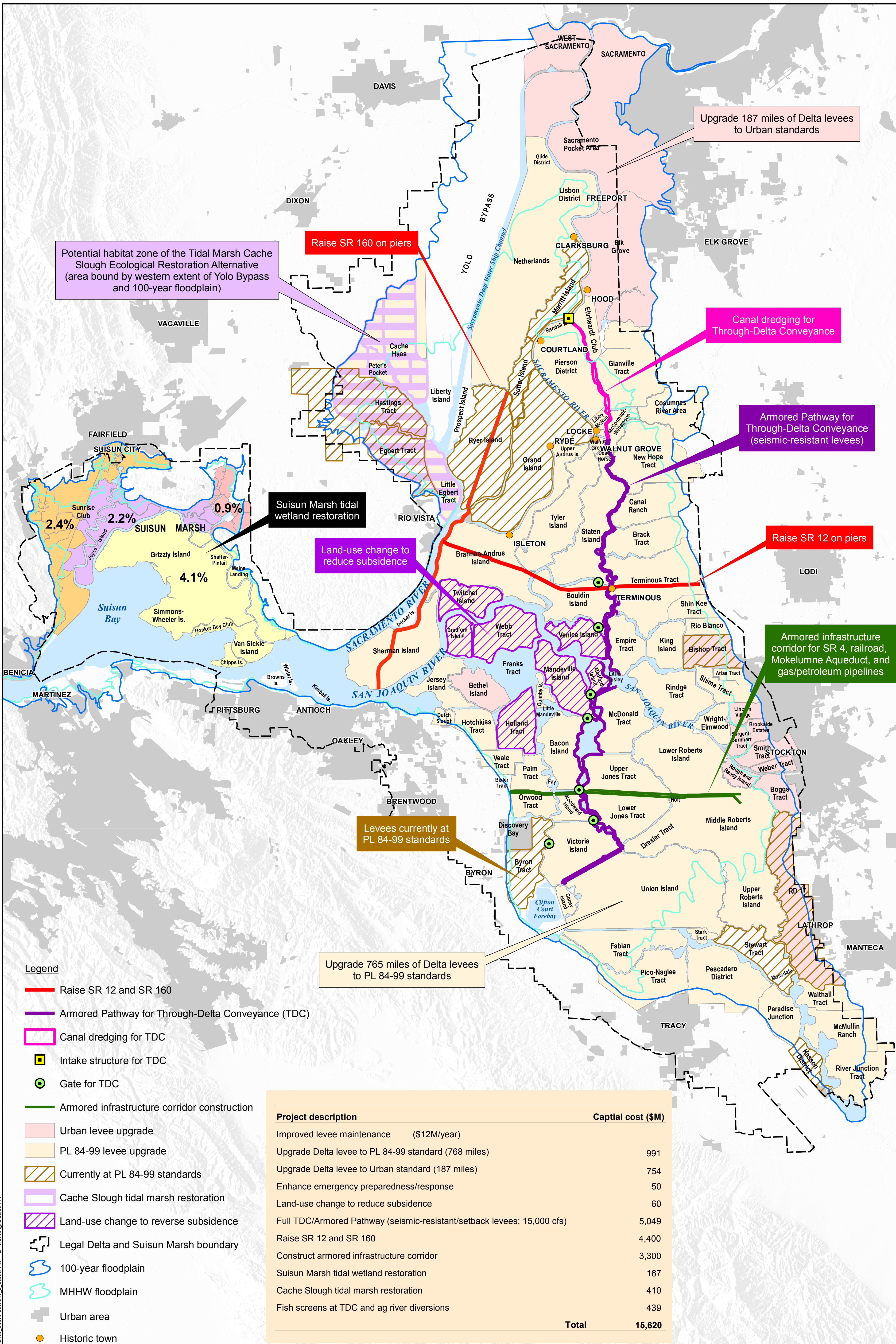


Figure 18-3b Expected Economic Impacts (Value of Lost Output) of Trial Scenarios at Different Years



Project description	Captial cost ($M)
Improved levee maintenance (\$12M/year)	
Upgrade Delta levee to PL 84-99 standard (768 miles)	991
Upgrade Delta levee to Urban standard (187 miles)	754
Enhance emergency preparedness/response	50
Land-use change to reduce subsidence	60
Full TDC/Armored Pathway (seismic-resistant/setback levees; 15,000 cfs)	5,049
Raise SR 12 and SR 160	4,400
Construct armored infrastructure corridor	3,300
Suisun Marsh tidal wetland restoration	167
Cache Slough tidal marsh restoration	410
Fish screens at TDC and ag river diversions	439
Total	**15,620**

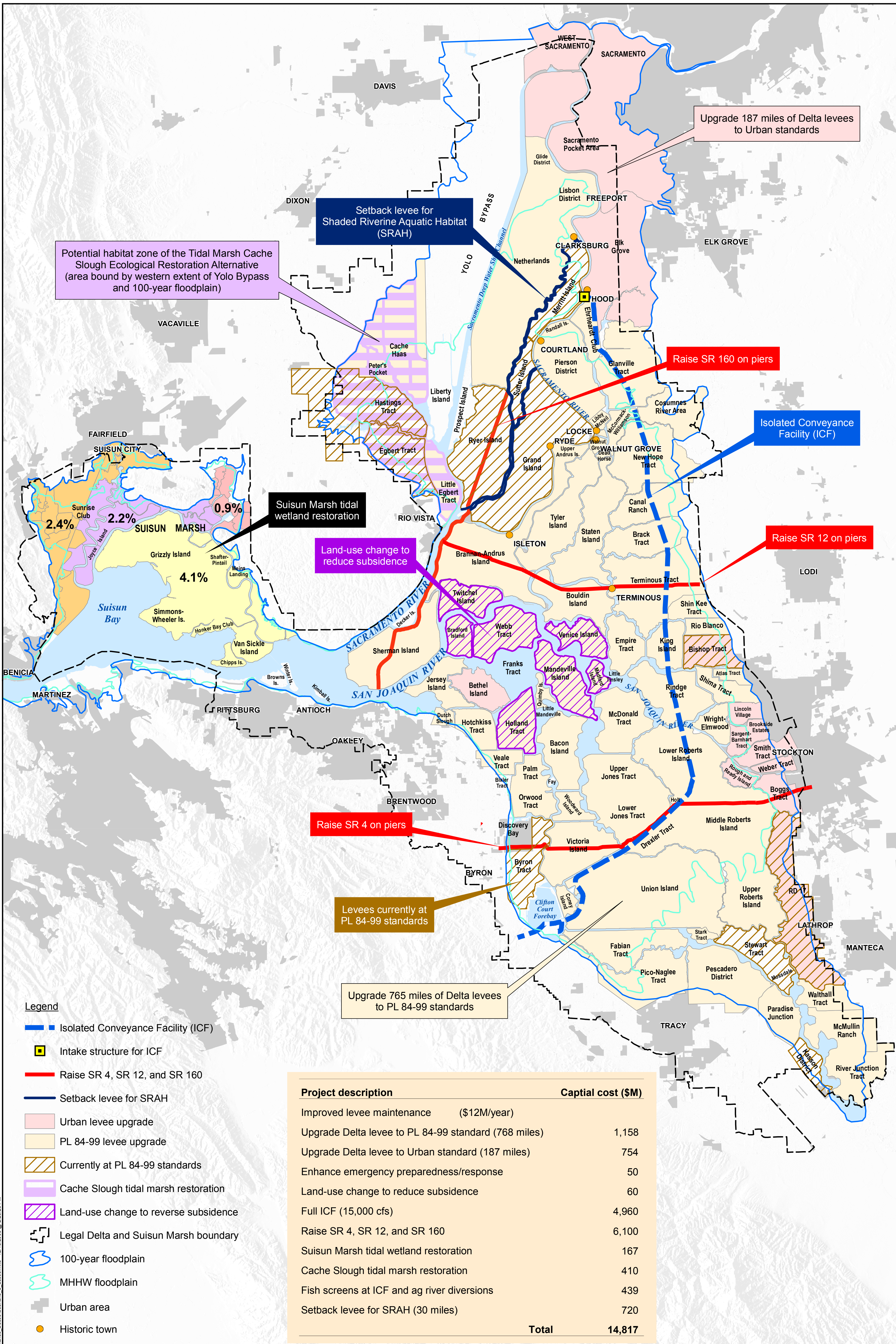
URS

Project No. 26815935

Delta Risk Management Strategy (DRMS)
Phase 2
10 Dec 2008

Trial Scenario 2:
Through-Delta Conveyance
(Armored Pathway)

Figure 18-4



Project description		Captial cost ($M)
Improved levee maintenance	($12M/year)	
Upgrade Delta levee to PL 84-99 standard (768 miles)		1,158
Upgrade Delta levee to Urban standard (187 miles)		754
Enhance emergency preparedness/response		50
Land-use change to reduce subsidence		60
Full ICF (15,000 cfs)		4,960
Raise SR 4, SR 12, and SR 160		6,100
Suisun Marsh tidal wetland restoration		167
Cache Slough tidal marsh restoration		410
Fish screens at ICF and ag river diversions		439
Setback levee for SRAH (30 miles)		720
	Total	14,817

P:\GIS\GIS_Phase_II_Project_Files\MXD\Scenarios_Dec08\Scenario_3_dec08.mxd - 12/18/2008 @ 2:29:20 PM

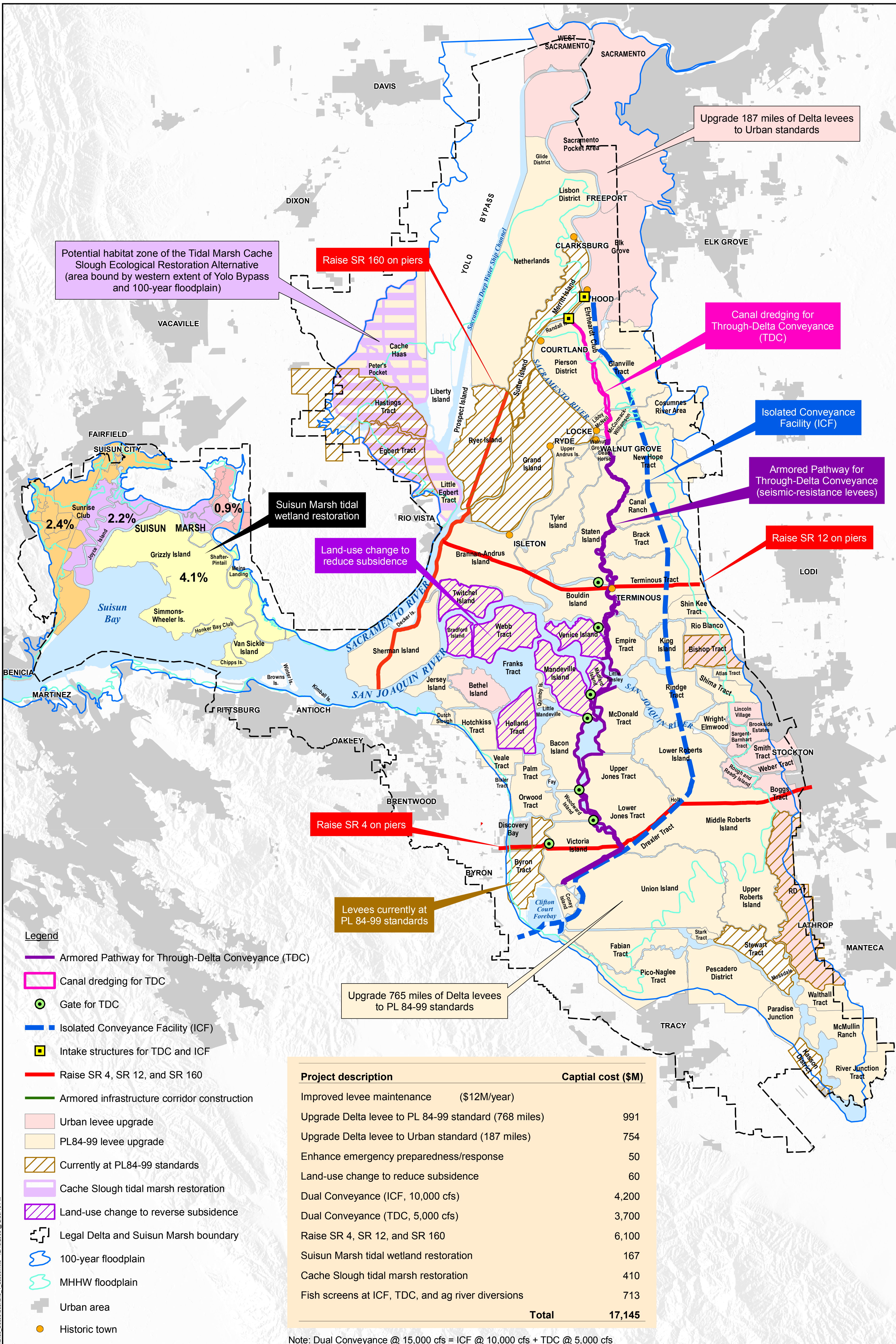
URS

Project No. 26815935

Delta Risk Management Strategy (DRMS)
Phase 2
10 Dec 2008

Trial Scenario 3:
Isolated Conveyance Facility

Figure
18-5



Project description		Captial cost ($M)
Improved levee maintenance	($12M/year)	
Upgrade Delta levee to PL 84-99 standard (768 miles)		991
Upgrade Delta levee to Urban standard (187 miles)		754
Enhance emergency preparedness/response		50
Land-use change to reduce subsidence		60
Dual Conveyance (ICF, 10,000 cfs)		4,200
Dual Conveyance (TDC, 5,000 cfs)		3,700
Raise SR 4, SR 12, and SR 160		6,100
Suisun Marsh tidal wetland restoration		167
Cache Slough tidal marsh restoration		410
Fish screens at ICF, TDC, and ag river diversions		713
	Total	**17,145**

Note: Dual Conveyance @ 15,000 cfs = ICF @ 10,000 cfs + TDC @ 5,000 cfs

URS

Project No. 26815935

Delta Risk Management Strategy (DRMS)
Phase 2
10 Dec 2008

Trial Scenario 4:
Dual Conveyance

Figure
18-6

P:\GIS\GIS_Phase_II_Project_Files\MXD\Scenarios_Dec08\Scenario_4_dec08.mxd - 12/18/2008 @ 2:30:43 PM